Eddy modulation of air-sea heat fluxes

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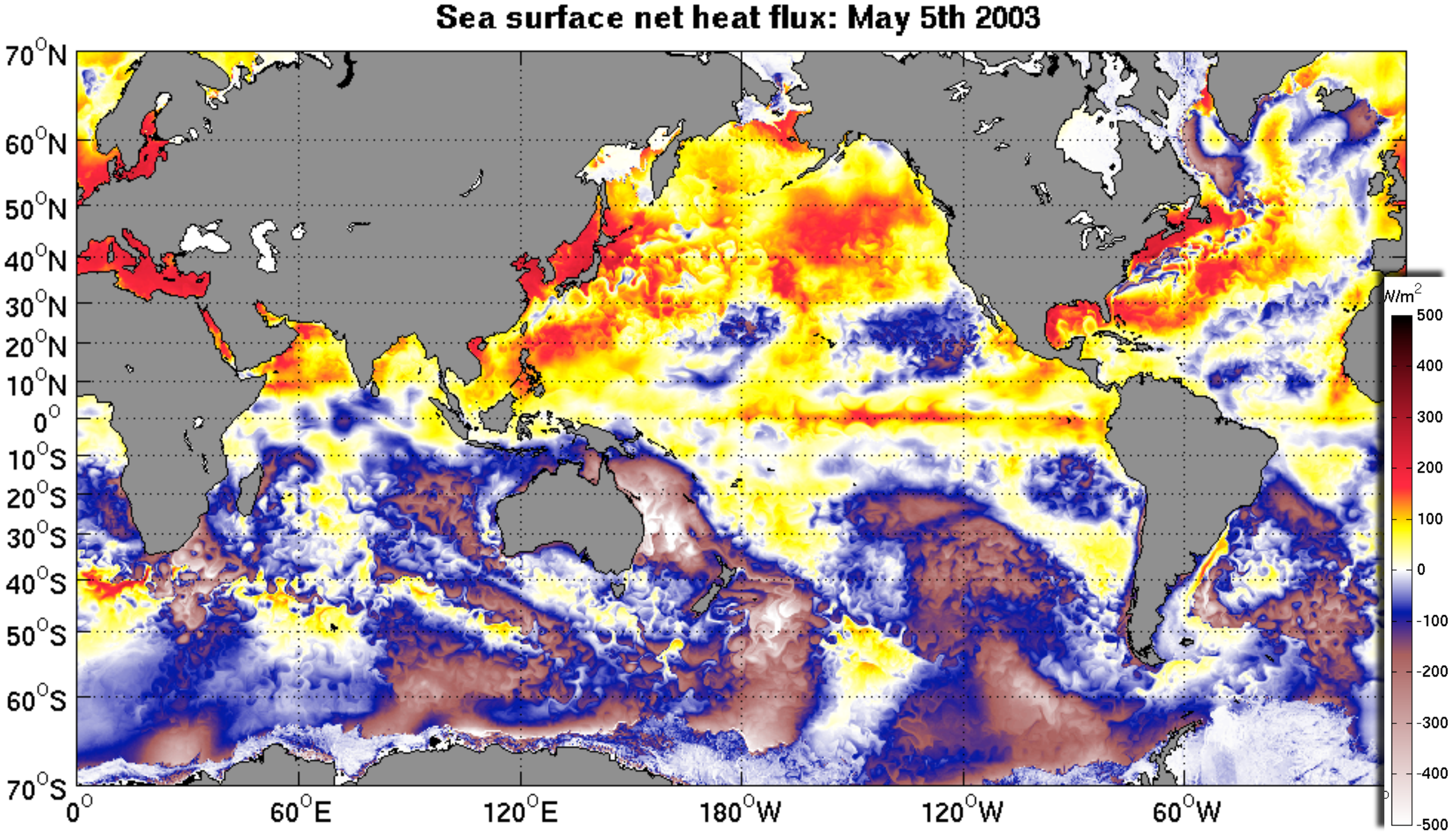
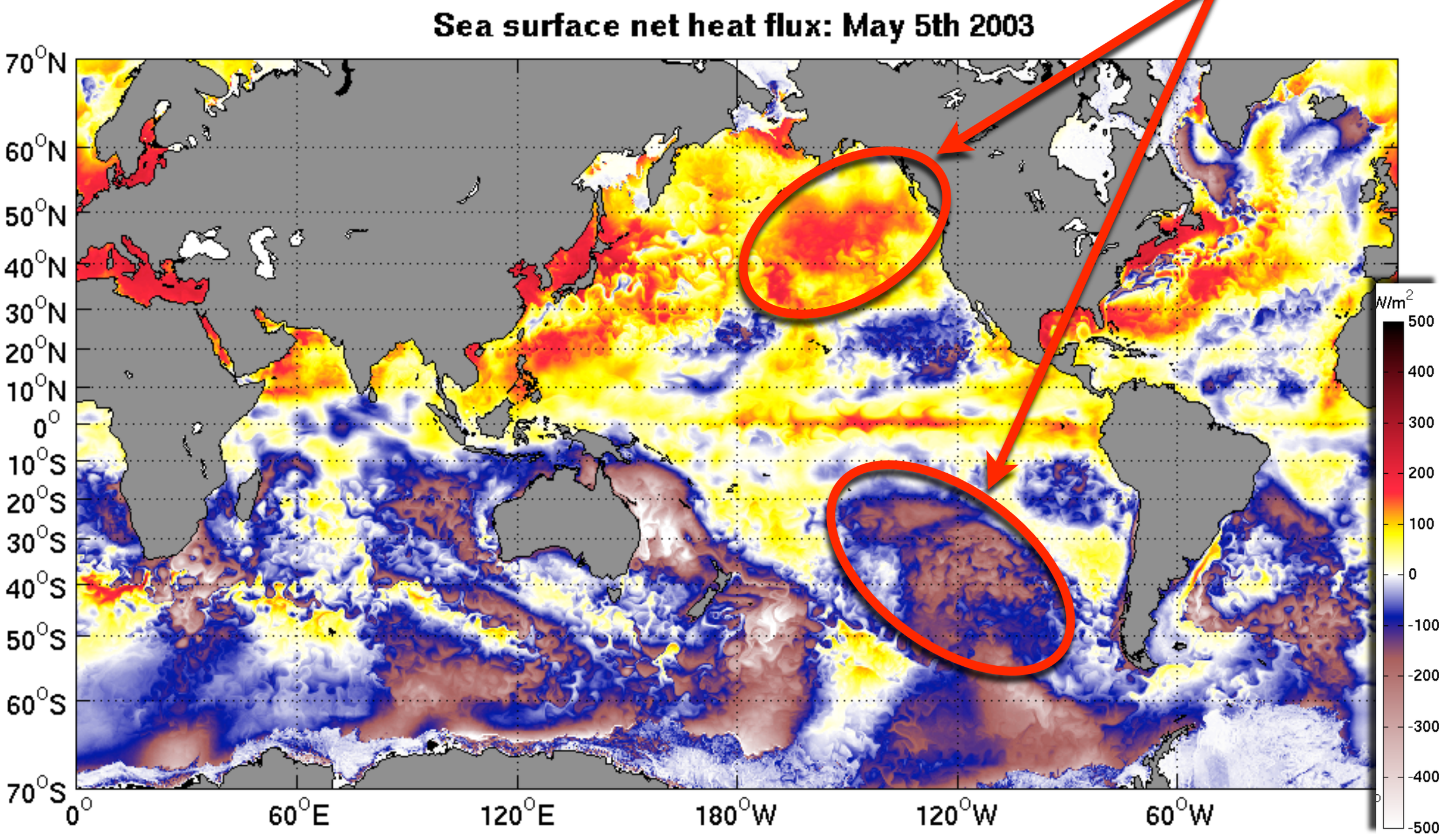
ECCO2 Meeting, Sept.23-24/2008


Sea surface net heat flux: May 5th 2003
70°N
60°N
50°N
40°N
30°N
20°N
10°N
0°
10°S
20°S
30°S
40°S
50°S
60°S
70°S
0°
60°E
120°E
180°W
120°W
60°W
W/m2
500
400
300
200
100
0
-100
-200
-300
-400
-500

I/8, II2.nb.01

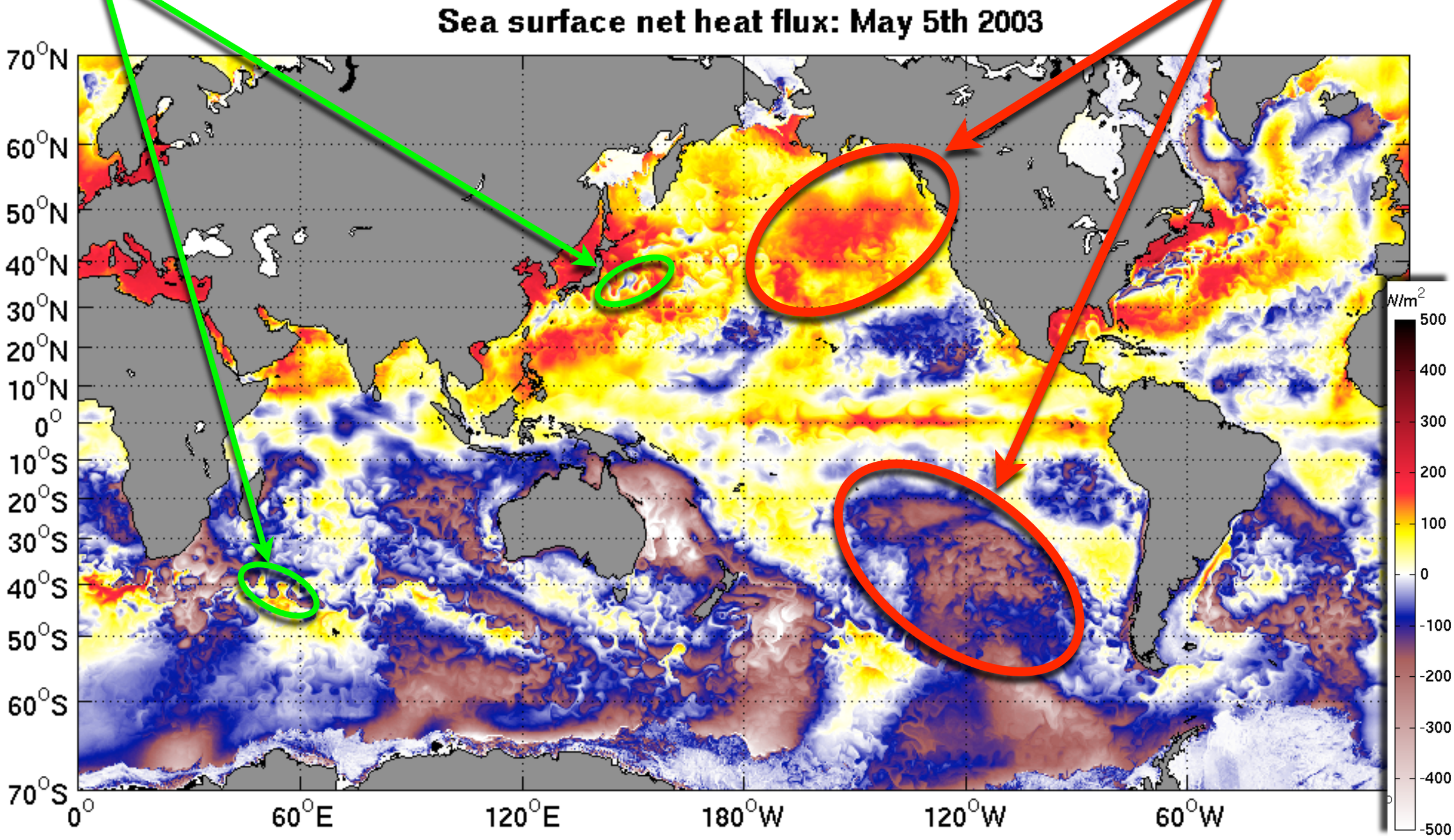
Rapid atmospheric synoptic scale



1/8, 112.nb.01

Oceanic mesoscale

Rapid atmospheric synoptic scale



I/8, II2.nb.01

Sea surface net heat flux: May 5th 2003

70°N 60°N 50°N 40°N 30°N 20°N 10°N 0° 10°S 20°S 30°S 40°S 50°S 60°S 70°S

0° 60°E 120°E 180°W 120°W 60°W 0°

Kuroshio

Gulf Stream

50°N 45°N 40°N 35°N 30°N 25°N 20°N

130°E 140°E 150°E 160°E 170°E 180°W 80°W 70°W 60°W 50°W 40°W 30°W

SST contours in black

Sea surface net heat flux: May 5th 2003

Kuroshio

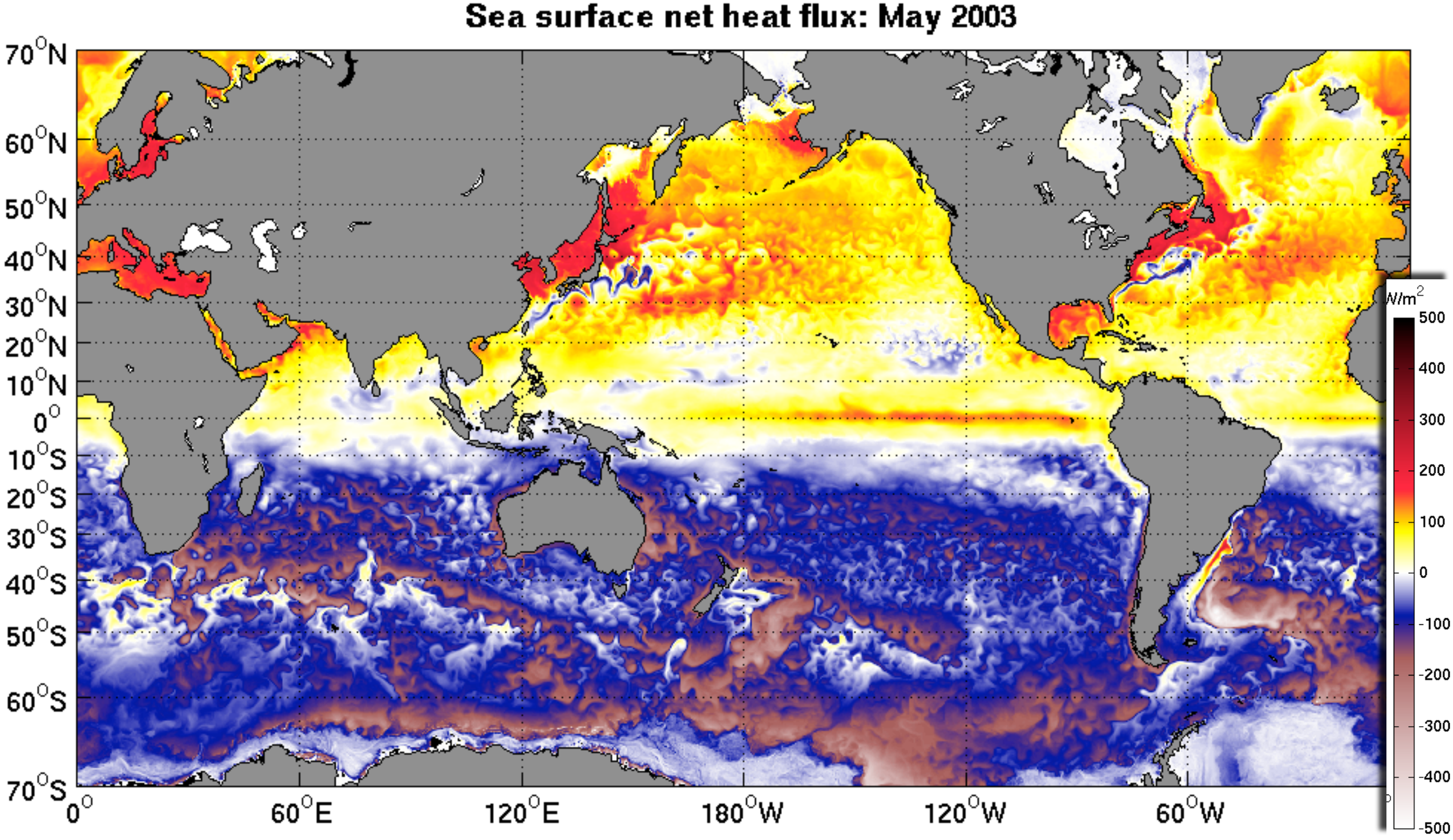
T

Q

SST contours in black

MONTHLY
Mean

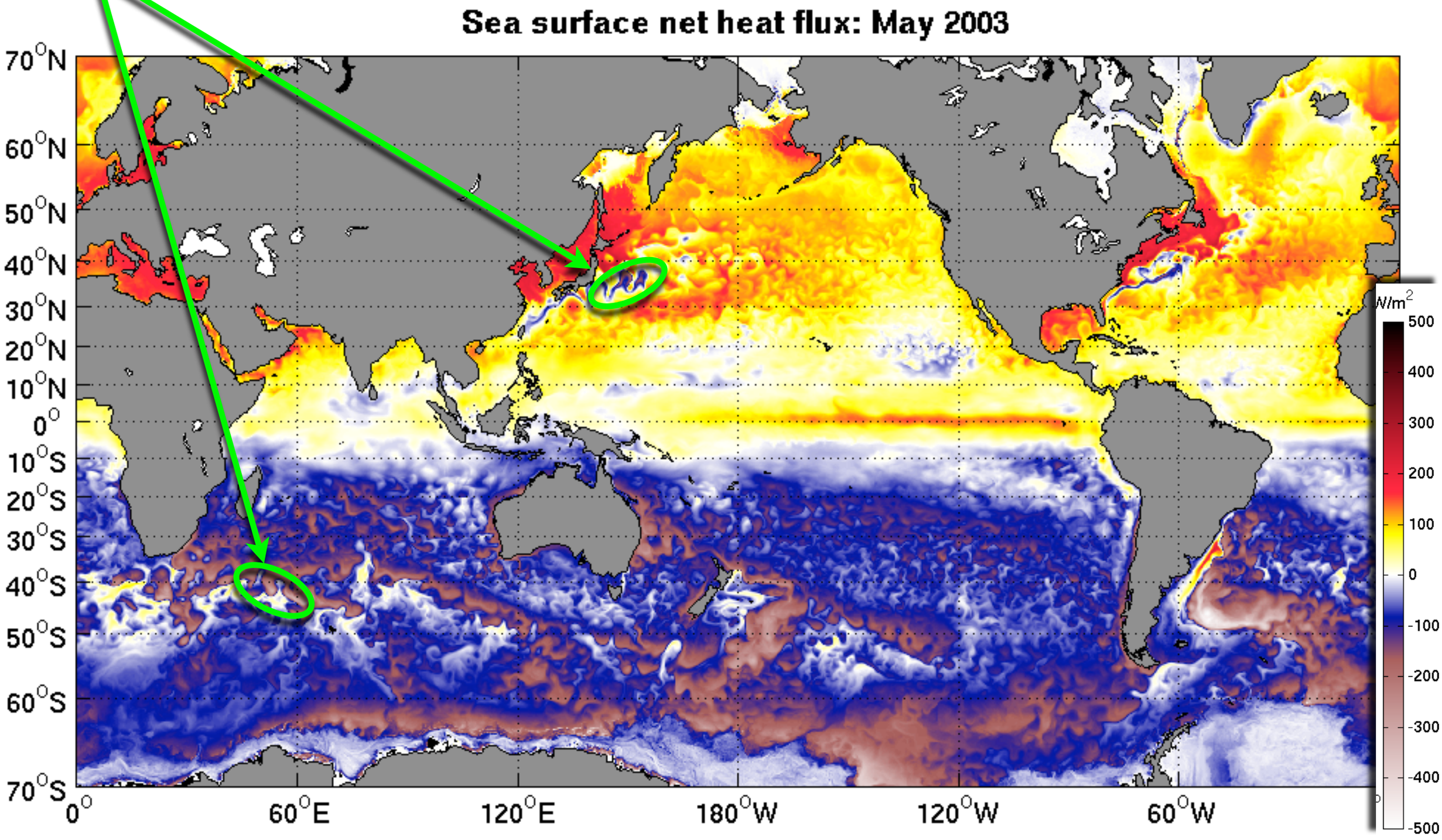
Atmospheric synoptic scale averaged out

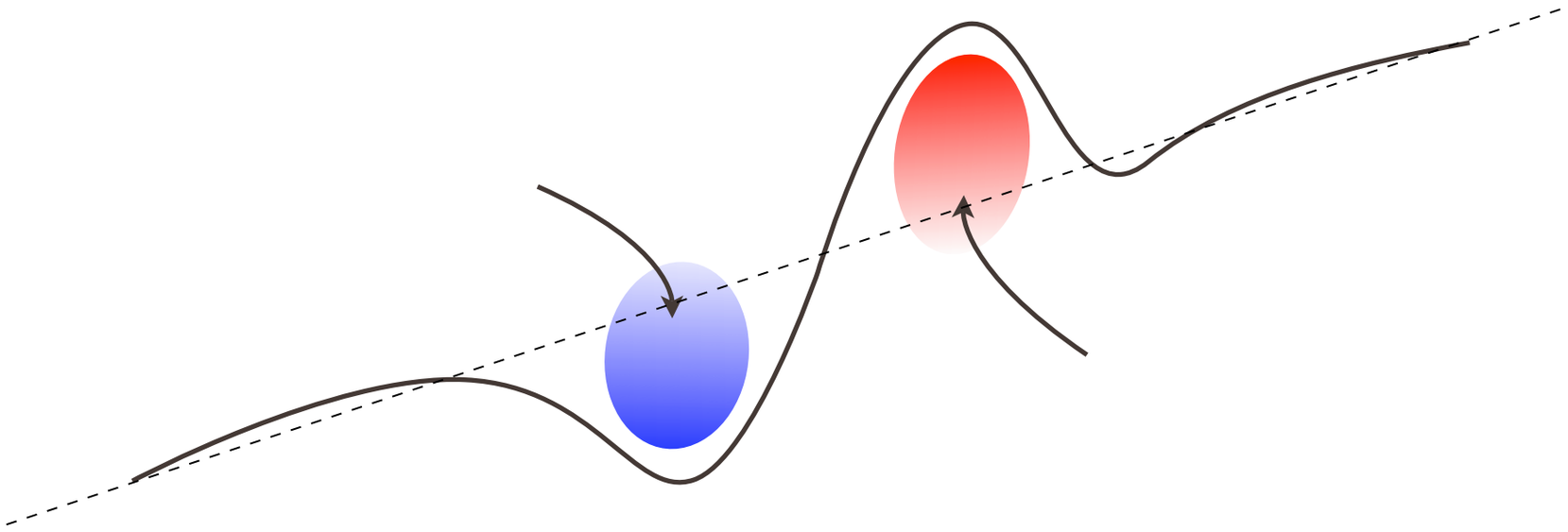


Huge spatial variability set by oceanic mesoscale

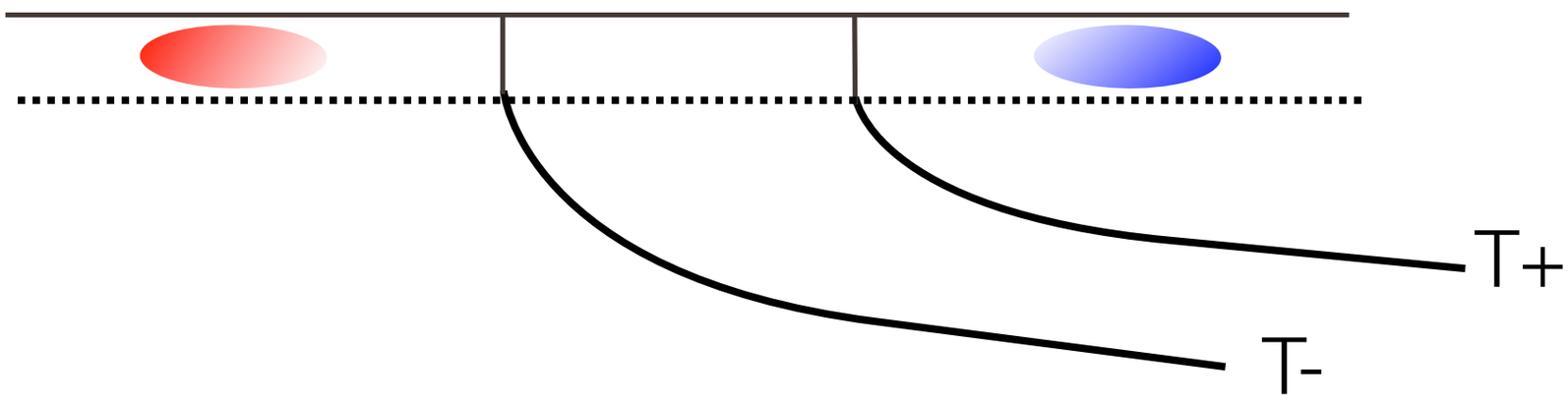
MONTHLY Mean

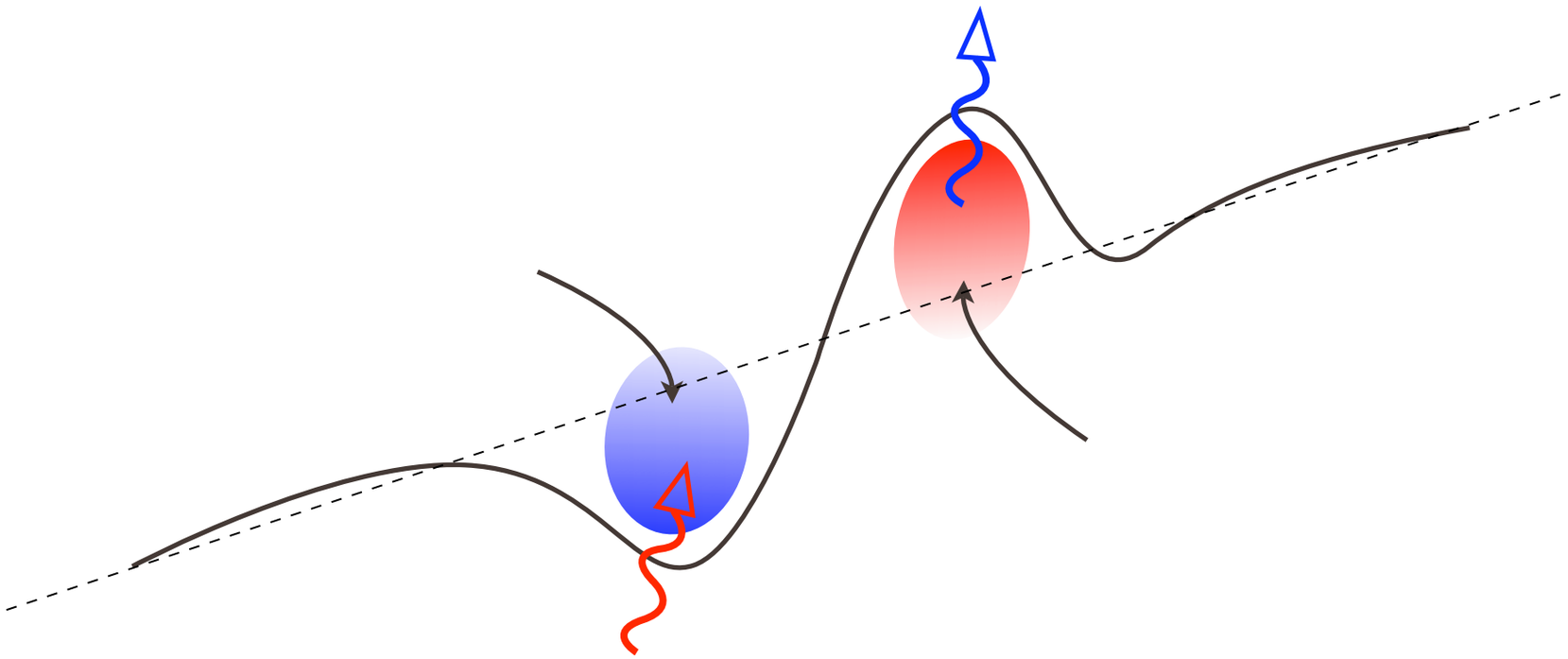
Atmospheric synoptic scale averaged out





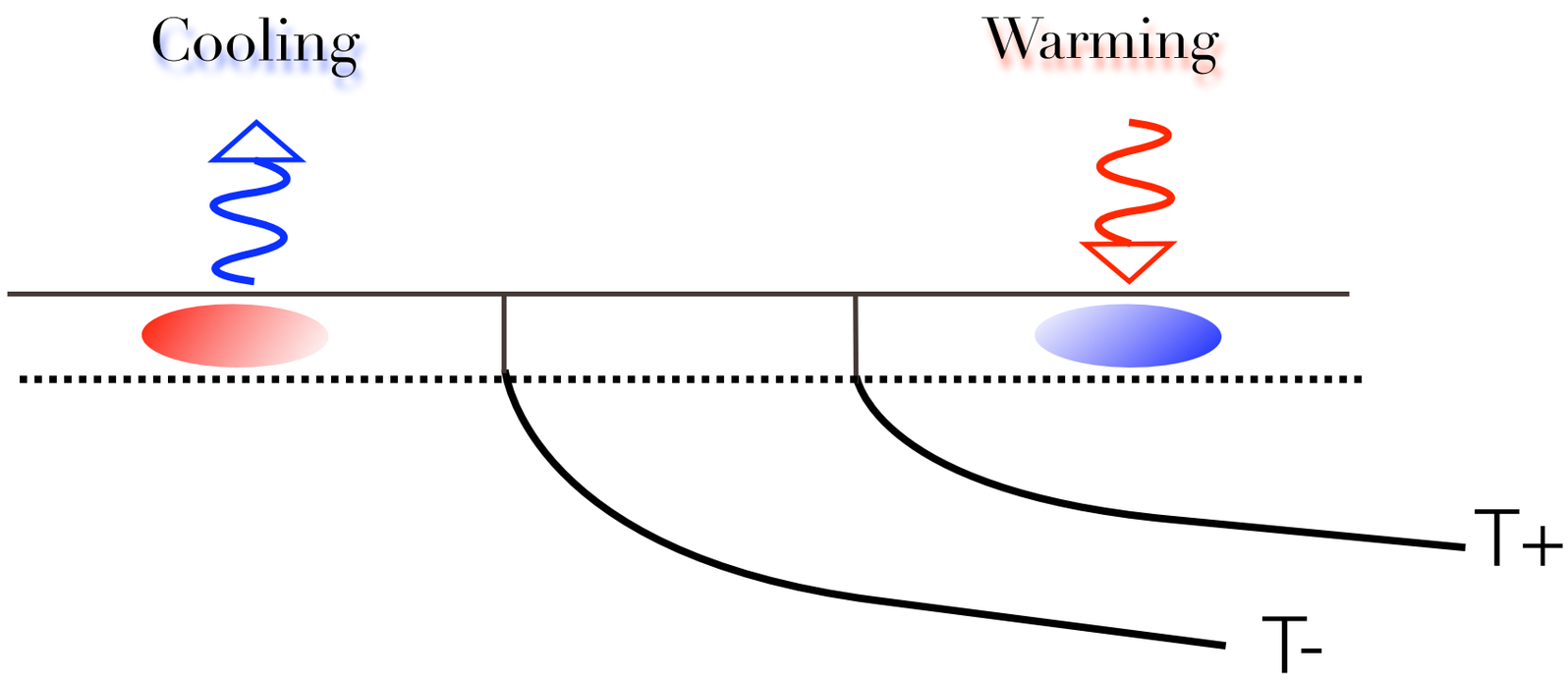
Eddies advect anomalous warm/cold water

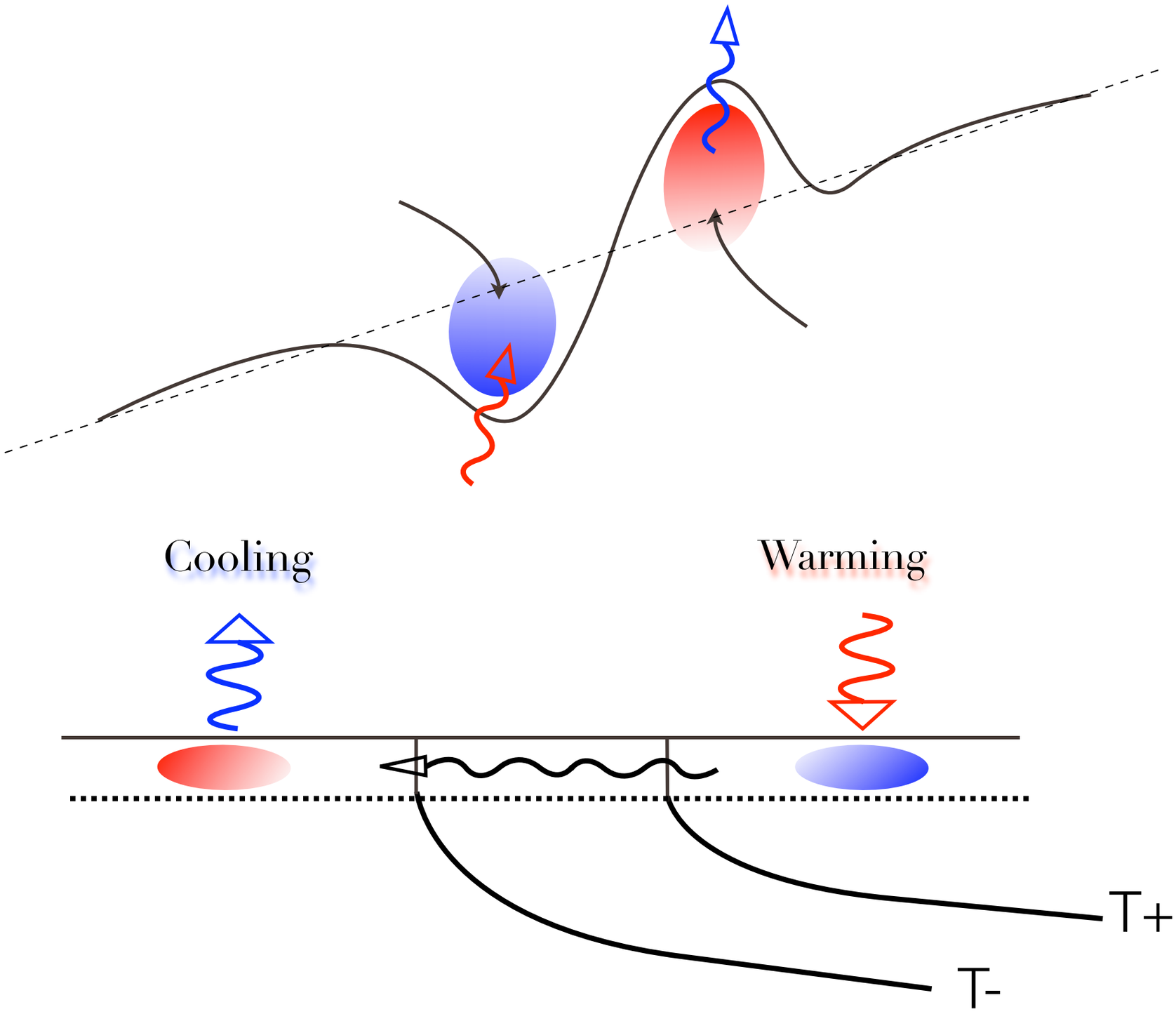




Eddies advect anomalous warm/cold water

which are strongly damped

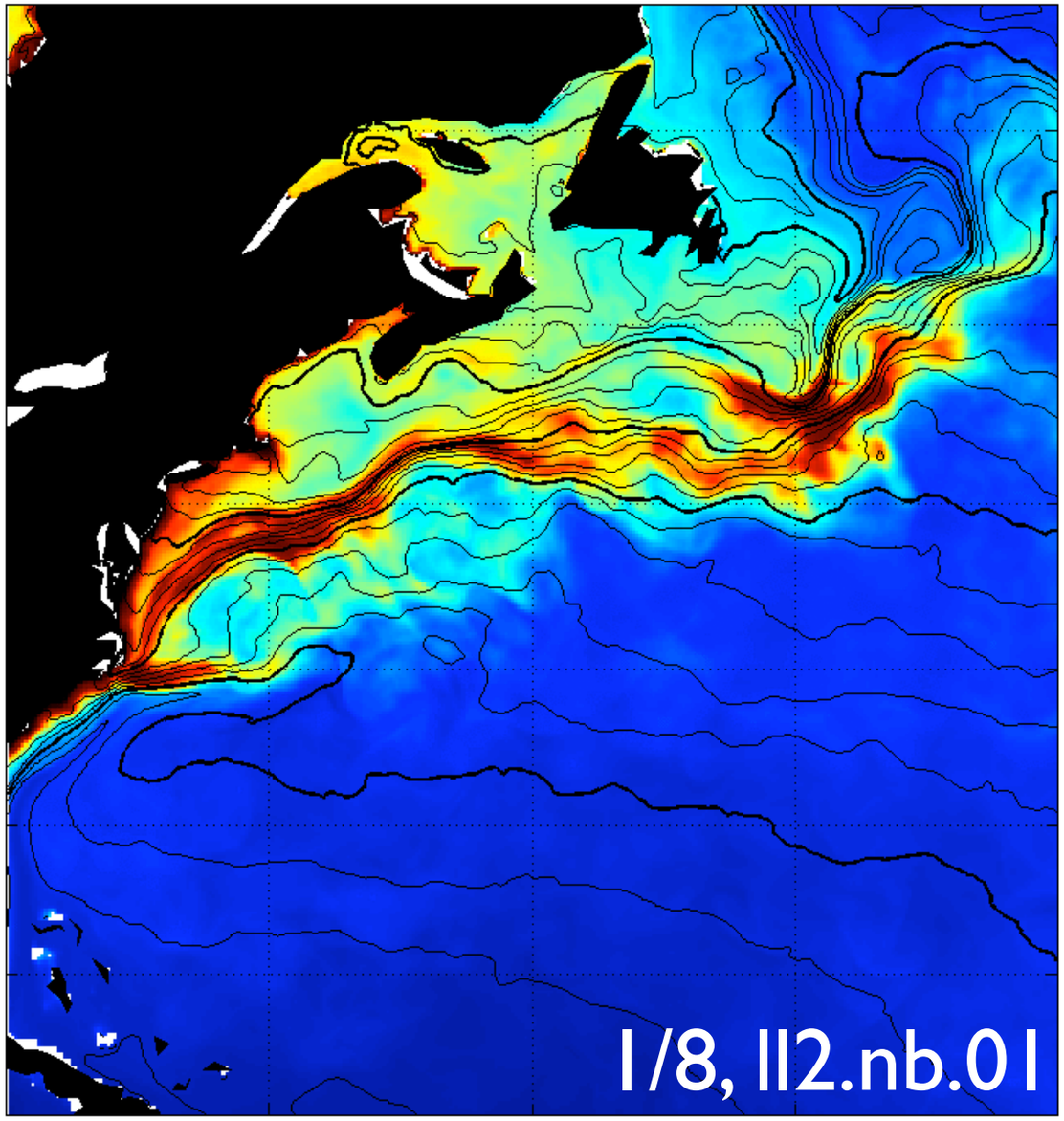


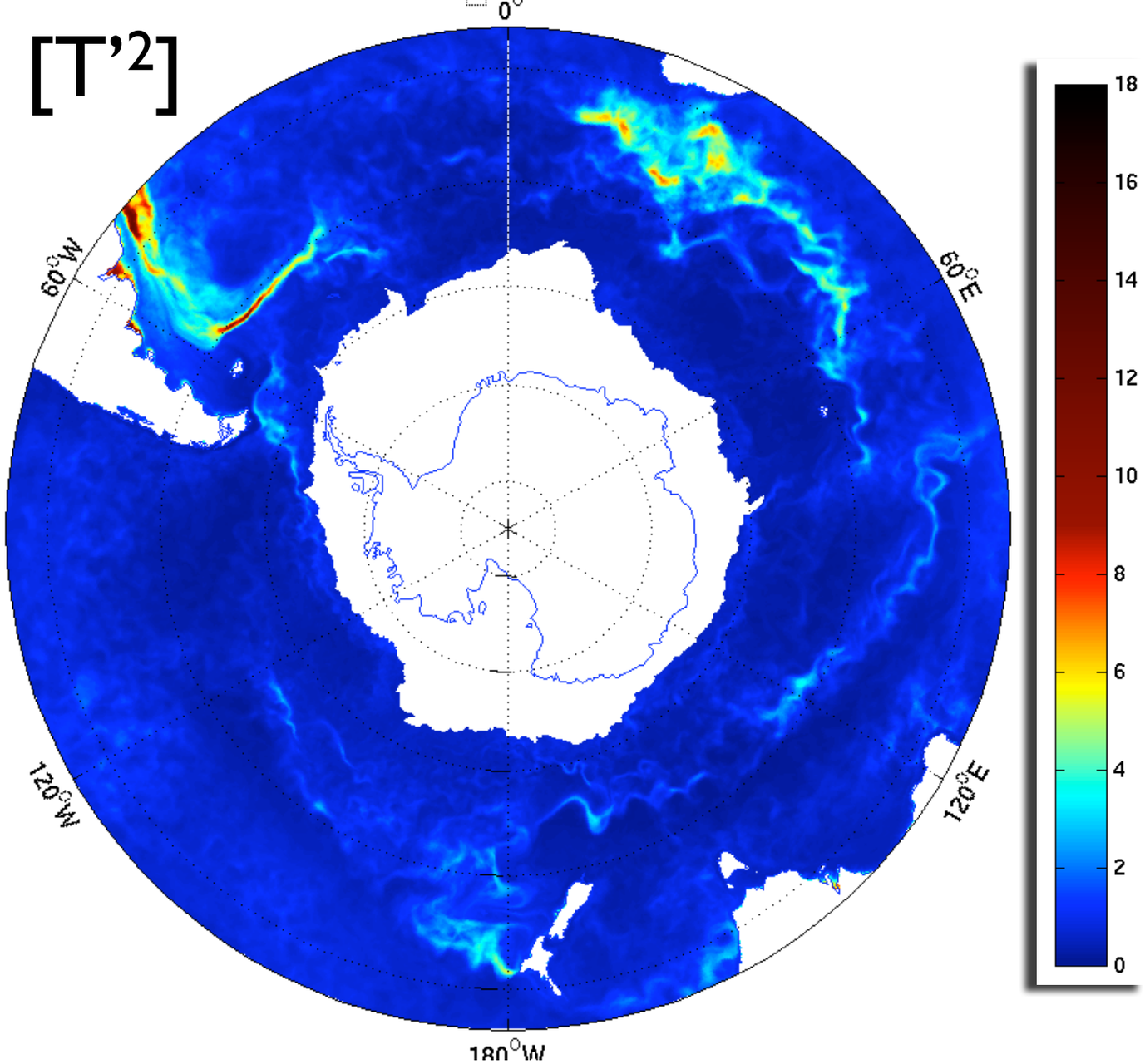


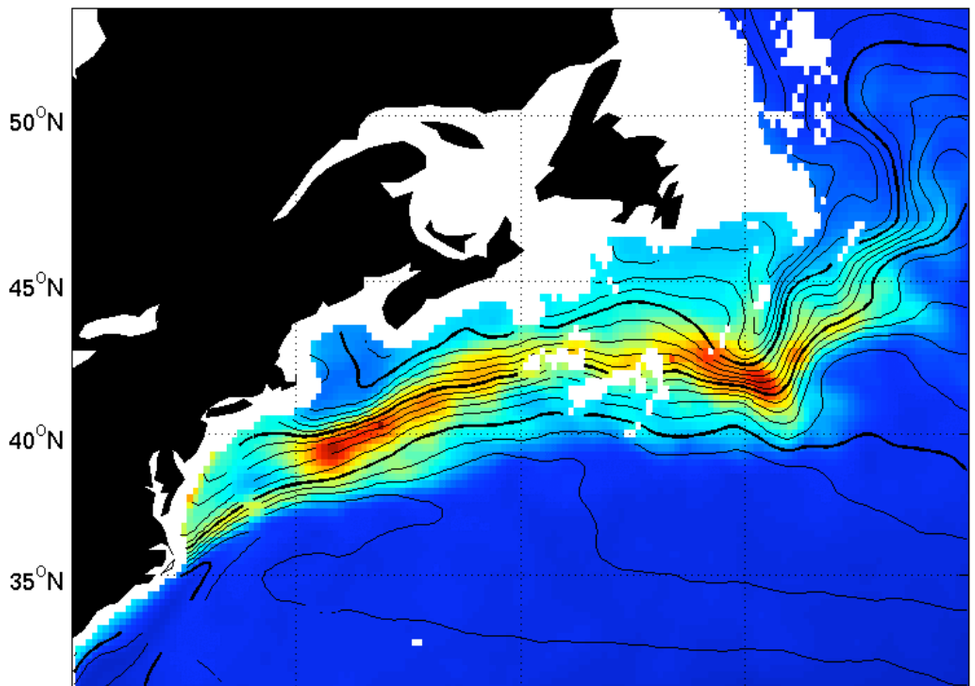
Eddies advect anomalous warm/cold water

which are strongly damped

leading to a lateral eddy flux



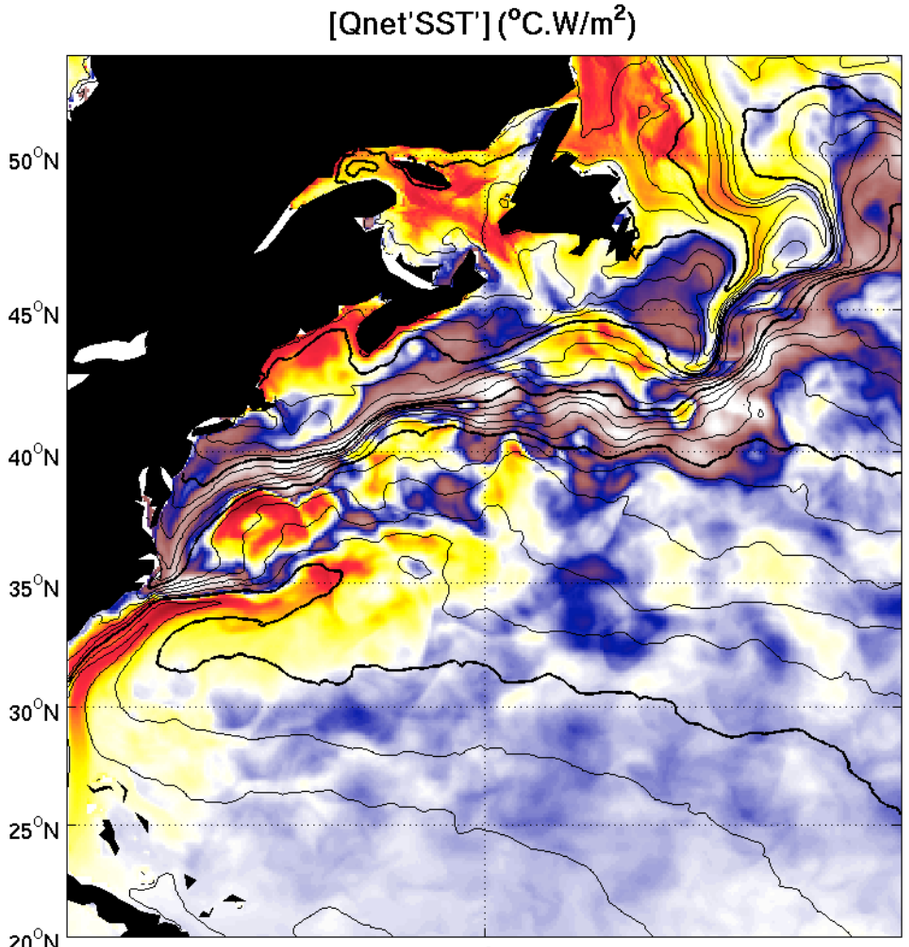


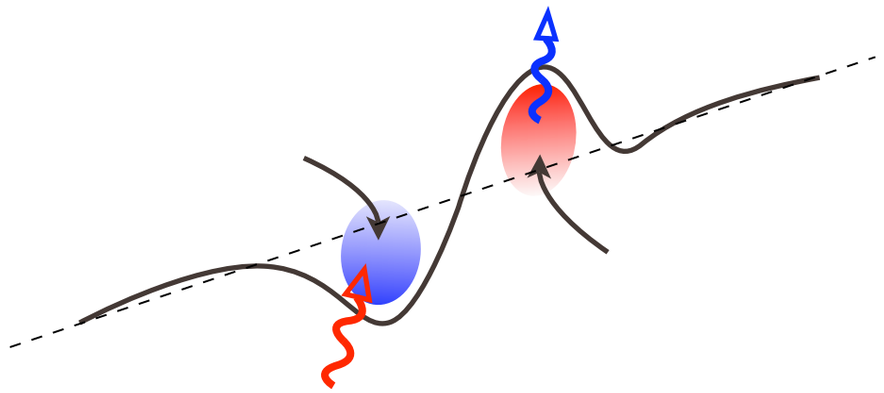


SST Eddy field

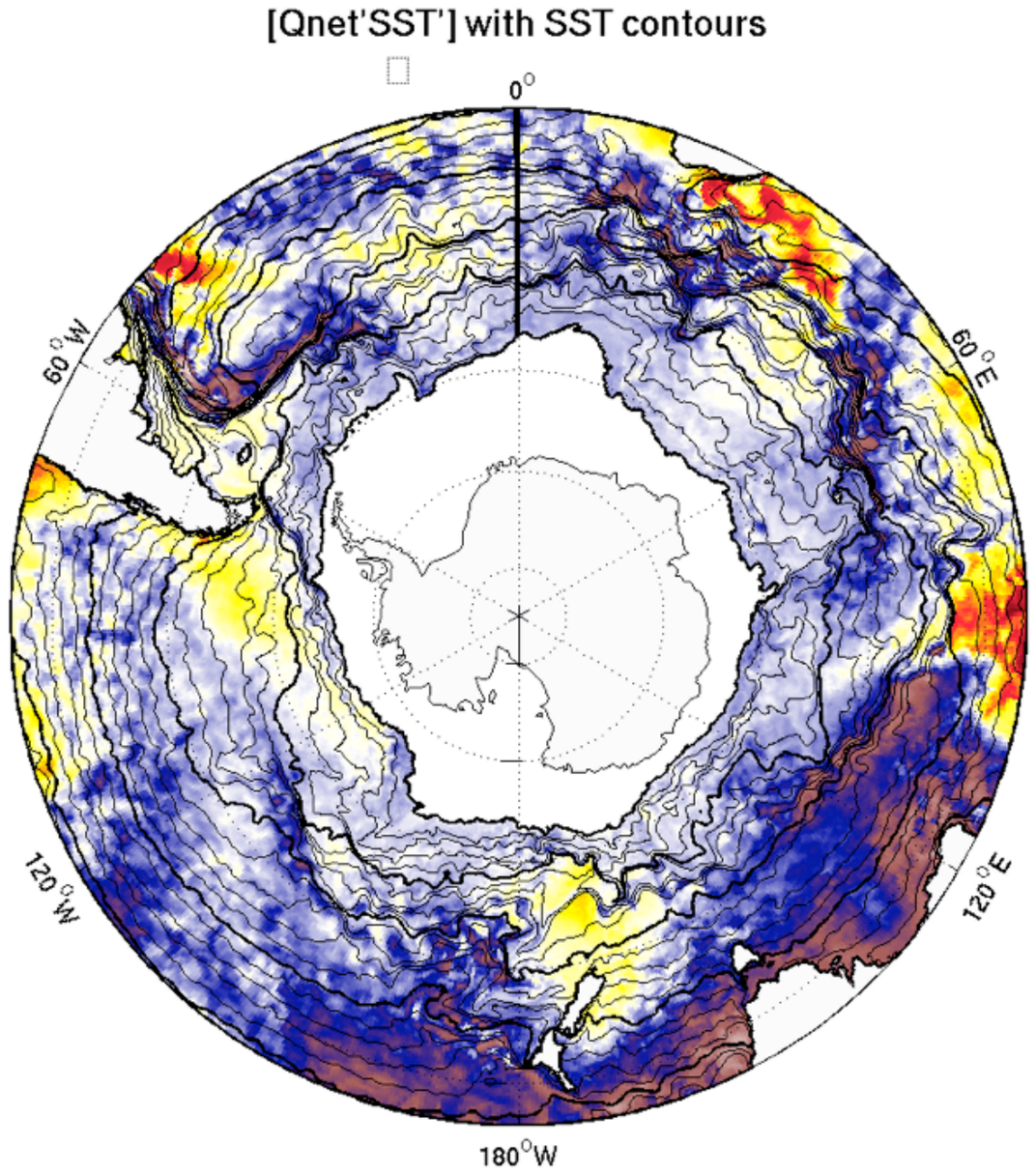
$$[T'^2] = [T^2] - [T^{sc2}] - [T]^2$$

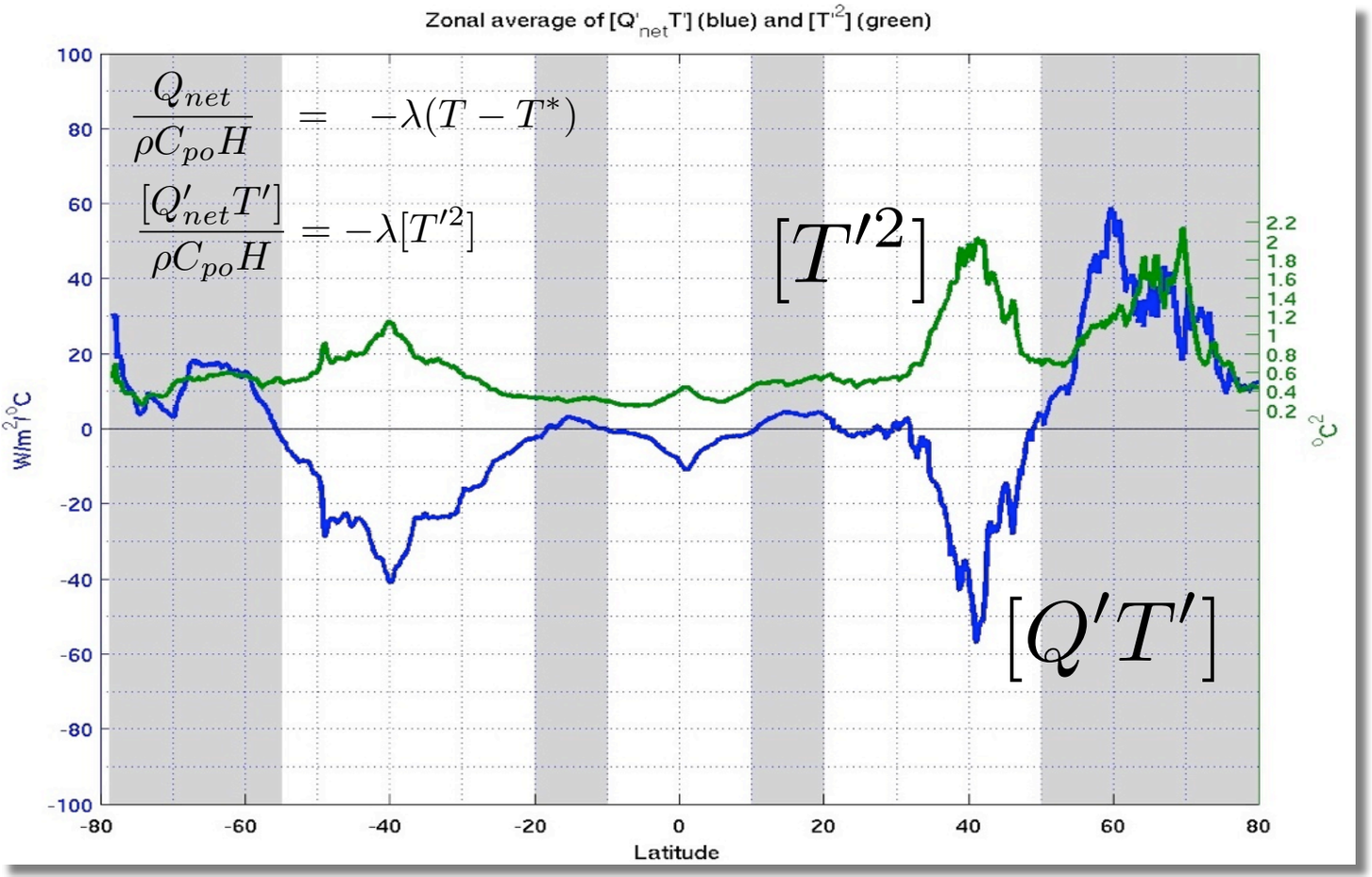
1/4 Satellite SST (RMSS)





$$[Q'T'] = [QT] - [Q^{sc}T^{sc}] - [Q][T]$$



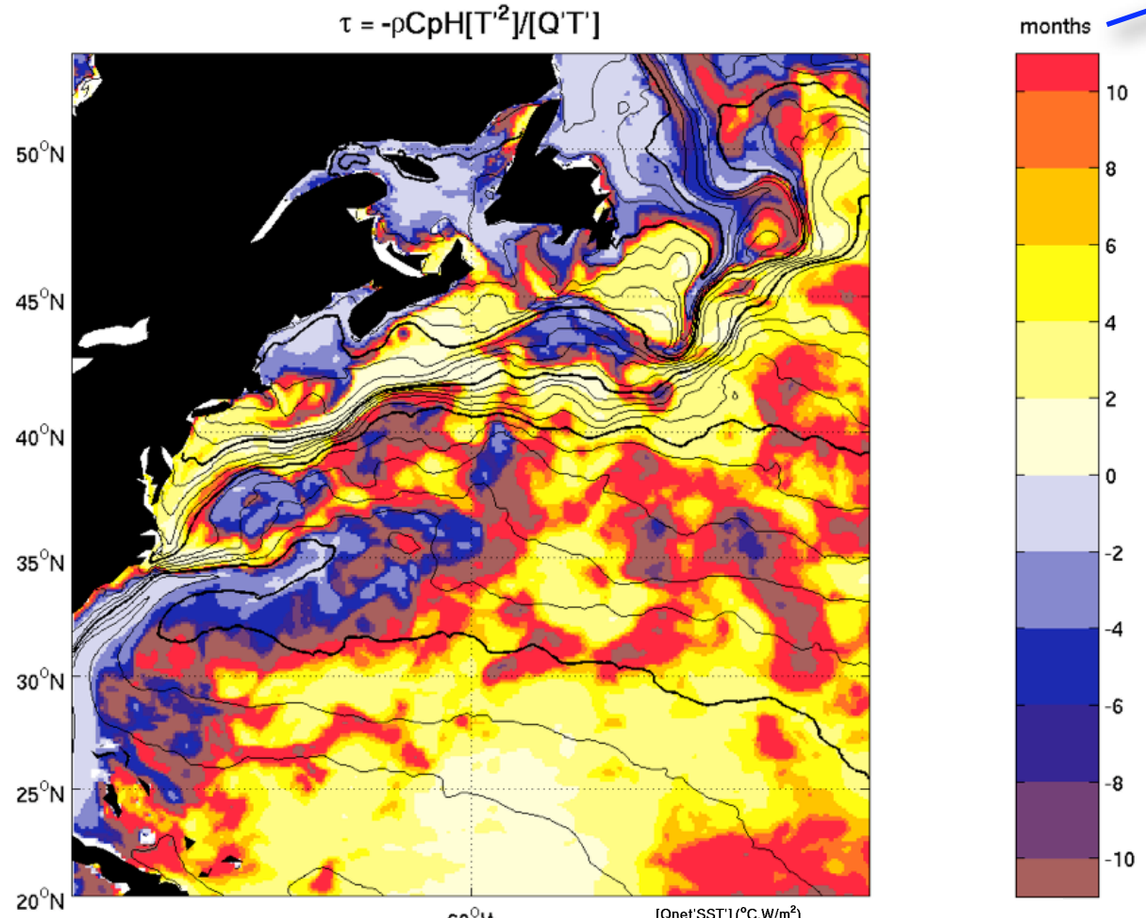


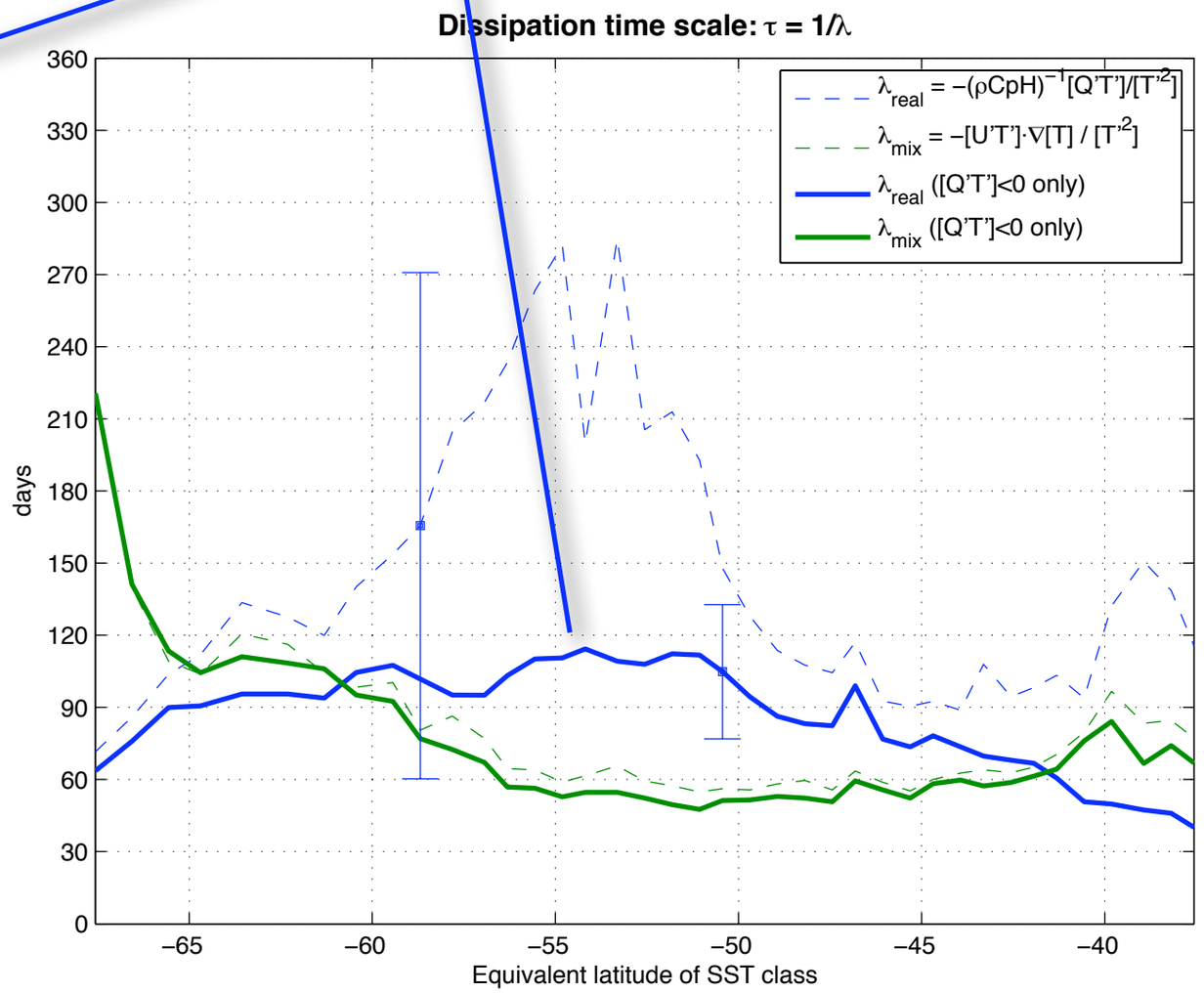
Damping time scale

$$\frac{Q_{net}}{\rho C_{po} H} = -\lambda(T - T^*)$$

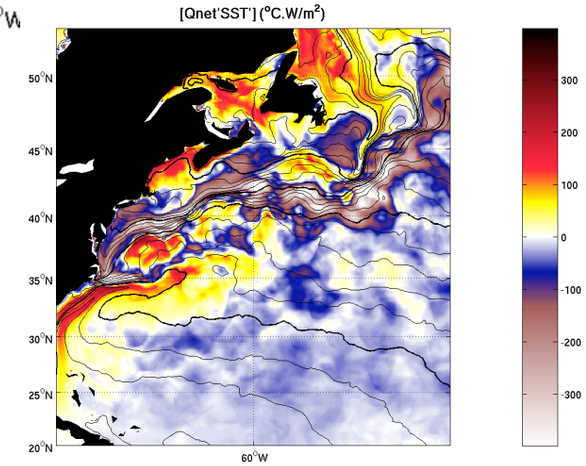
$$\frac{[Q'_{net} T']}{\rho C_{po} H} = -\lambda[T'^2]$$

$$\frac{1}{\lambda} = -\rho C_{po} H \frac{[T'^2]}{[Q'_{net} T']}$$



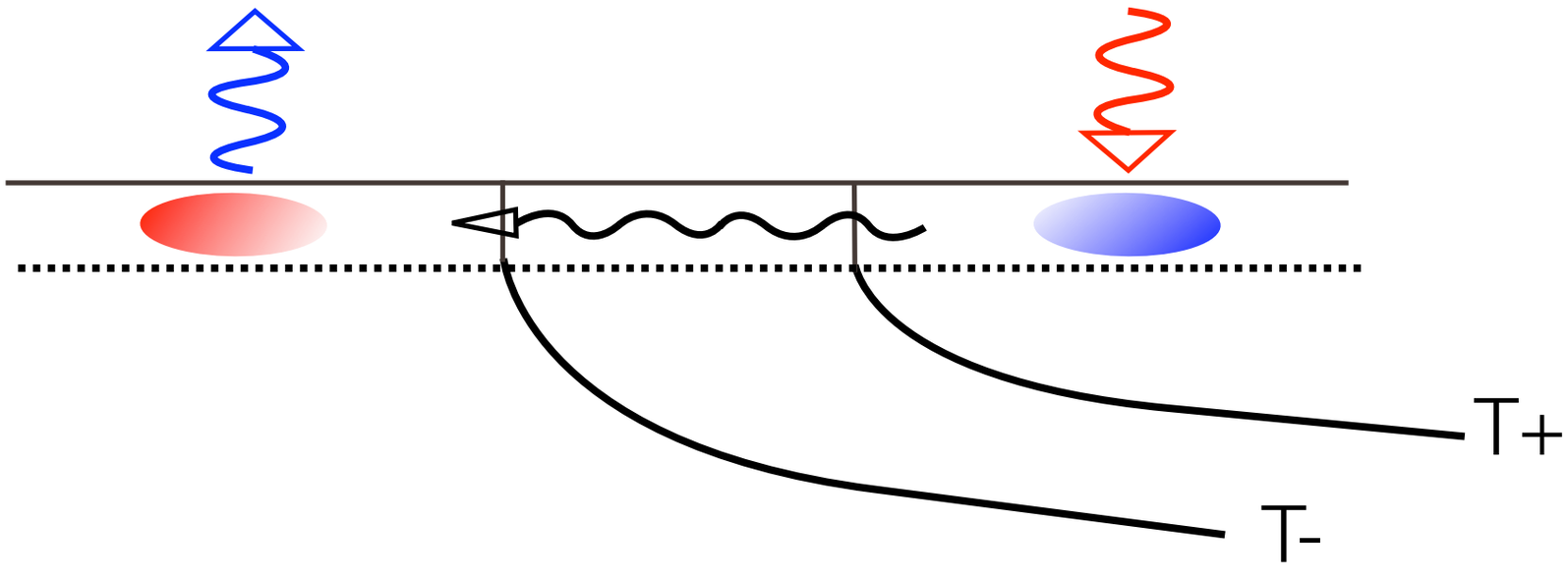


$[Q'T']$



Conclusion

- The presence of mesoscale eddy field systematically modulates air-sea heat fluxes
- Air-sea heat fluxes tend to damp SST anomalies on a timescale of 2->6 months
- It induces a lateral eddy heat flux through the mixed layer



The lateral eddy flux may be estimated as an Eddy Diffusivity coefficient:

$$
\begin{aligned}
K_{sea}^{air} &= \frac{-1}{\rho C_{po} H} \frac{[Q'_{net} T']}{\nabla[T] \cdot \nabla[T]} \\
-\frac{[Q'_{net} T']}{\rho C_{po} H} &= \lambda [T'^2] \\
K_{sea}^{air}([T'^2]) &= \lambda \frac{[T'^2]}{\nabla[T] \cdot \nabla[T]}
\end{aligned}
$$

which adds up to the horizontal background eddy diffusivity in the mixed layer